An empirical estimation of long-period earthquake ground motion (1) -Standard attenuation relation and assessment of shakeability-

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1. INTRODUCTION

The site including path effects to the long-period (1-15 sec.) ground motion (LPGM) in land Japan were estimated by Okada and Kagami (1978), Mamula et al. (1984), and Zama (2000). Those results show the strong spatial or regional variation of LPGM. However, these estimated sites or regions are limited at only the observation sites (about 100 sites in whole Japan) of Japan Meteorological Agency (JMA). Recently, Kataoka et al. (2006) obtained statistically the average spectral predictive model using records of many strong motion sites and estimated the relative LPGM shakeability as a function of period, however, the meaning of 'average' is uncertain with respect to site geology or geotechnical data.

In order to clearly recognize the shakeability we first obtain a standard attenuation relation of spectral ground motion on hard rock sites. Next, we estimate shakeability of LPGM at a site by spectral ratio to the standard attenuation model.

2. A STANDARD ATTENUATION MODEL AND DATA

To determine a standard attenuation model at hard rocks, we used the KiK-net data from moderately large earthquakes of 15 (large moment magnitudes than 5.7 and shallower depths than 60 km, determined by F-net) since 1996. The definition of 'hard rock sites' is that the S-wave velocity at down-hole and / or surface sites based on the geotechnical data of KiK-net exceeds 2.0 km/sec. In addition, we excluded sites that amplification factors (ratio of surface to downhole motions) were larger than a factor of two at longer period than 1 sec., in order to avoid the effects of reflected subsurface layers to the hard rock motion. The number of such defined sites is 161 among about 670 sites of KiK-net.

We applied 1,540 horizontal motions from 15 earthquakes at hard rock sites of the KiK-net to compute response spectra with 5 percents damping S(T) for 70 periods in the range between 1 to 15 sec.. We simply use a standard attenuation model in the form,

$$\log S(T) = a(T)\, Mw - 0.5 \log X - b(T)\, X + c(T)$$

A two-step stratified regression analysis was applied to compute the coefficients a(T), b(T), and c(T). First, we obtained b(T) by assuming coefficients a(T) and c(T) to be a single variable. Next, we computed coefficients a(t) and c(t) using the determined coefficient b(T) by a first step. In this study, we use geometrical dumping of 0.5 postulating multi-mode surface waves.

4. SHAKEABILITY IN LAND JAPAN

We define 'shakeability' simply by the ratio of a response spectrum at a site j, Sj(T), to that of a standard model or a hard rock site. The strong motion data of K-NET and Kik-net from larger moment magnitude earthquakes of 5.7 were finally used after consulting the quality of data.

We compared the results with Okada and Kagami (1978), Mamula et al. (1984) and the pattern of shakeability was quite similar to them. The high levels of shakeability were found at Obihiro, Sakata, Niigata, Tokyo, Yokohama, Osaka, Oita and Kagoshima, while the low level sites were. Sanriku coastal region, Izu peninsula, Kii peninsula and Chugoku districts.

We examined to reproduce the observations using the standard attenuation model and the average sheakability, assuming the 2003 Tokachi-oki earthquake, results is quite similar to the observation, however; the shakeability at each site by adding one standard deviation to the average and the result is the same level.

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